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ABSTRACT

This overview of the role and impact of computers on education and instruction examines: (1) computing applications for instruction, types of computer systems for instructional computing, and current instructional computing uses; (2) planning for future implementation of instructional computing, management concerns, and implementation issues; and (3) instructional computing costs, cost effectiveness analysis, and comparative costs of computer systems for computer-assisted instruction. The conclusions and recommendations of the report concern the assumptions on which Florida public policy should be based, policy formulation, priorities for the implementation of policies, and support of the policy implementation. References are listed. (FM)

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MORE HANDS FOR TEACHERS

The Report of the Commissioner's Advisory Committee on Instructional Computing

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MORE HANDS FOR TEACHERS

Report of the Commissioner's Advisory Committee
on Instructional Computing

State of Florida
Department of Education
Tallahassee, Florida 32301
Ralph D. Turlington, Commissioner
February 1980

MAY 16 1980

SUMMARY OF COMMITTEE RECOMMENDATIONS

The Advisory Committee on Instructional Computing was appointed by the Commissioner of Education to develop recommendations concerning the use of instructional computing in Florida public schools. Based on a six-month study, the Committee has reached consensus on a group of assumptions and recommendations which may serve as the basis of public policy to be formulated by the Florida Legislature. The Committee's findings, described in detail in the body of this report, can be summarized as follows:

(1) Computer technology will play an increasingly pervasive and dominant role in American society in the next generation. Florida cannot afford not to invest immediately in this technology for use in Florida schools, colleges, and universities. Investment is needed (a) to prepare citizens for new employment in computer technology and upgrade the skills of those already employed to reflect changes brought about by technology, and (b) to realize the potential of computer technology for improving teaching and learning of the basic and advanced skills necessary for all individuals in the Florida educational system to continue life-long learning.

(2) There is an urgent need to begin planning now at the state level for the appropriate utilization of computer technology in education. The Florida Department of Education should be responsible for this planning and for facilitating the use of instructional computing in the following priority areas:

- Computers as a medium of instruction in the teaching of basic skills and problem-solving, and for use with handicapped students and low enrollment classes.
- Computers as an object of instruction for computer literacy for both teachers and students, and for training in data processing.

(3) Appropriate amendments to the existing statutes or new statutes should be considered by the Legislature to address appropriate utilization of instructional computing throughout the State of Florida. The adoption of technology should, however, be at the discretion of the individual educational agencies, without Legislative mandates.

(4) Adequate state level staff should be assigned to perform the following functions in support of instructional computing.

- o providing information and consultation on available hardware and software,
- o maintaining a catalog and inventory of available information and resources on instructional computing in Florida,
- o assisting in securing discounts on hardware and software,
- o providing technical assistance on individual problems related to instructional computing,
- o facilitating and coordinating the evaluation of instructional computing projects, and
- o providing leadership and assistance to Department of Education staff members in relation to the priorities recommended for policy implementation.

In addition, funding should be provided to promote and encourage appropriate and effective use of instructional computing in school districts and institutions.

PREFACE

This Instructional Computing Report has been prepared in compliance with the following proviso contained in the 1979 General Appropriations Act:

> Provided, the Department of Education shall conduct a study of the feasibility, cost effectiveness, and the role of computer assisted instruction for public education on or before March 15, 1980.

The Department of Education conducted this study with the assistance of an advisory committee appointed by the Commissioner of Education. The committee was composed of the following representatives from school districts, community colleges, and state universities:

Mr. William Cecil--Naples High School
Dr. Linton Deck (Co-Chairman)--Orange County School District
Dr. Wil Dershimer--Seminole Community College
Dr. Walter Dick--Florida State University
Mr. Henry Fraze--N.E. Senior High School, St. Petersburg
Dr. Mary Kantowski--University of Florida
Dr. J. Terrence Kelly (Co-Chairman)--Miami-Dade Community College
Dr. Tom Mason--Florida A & M University
Dr. Jack McAfee--Indian River County School District
Dr. Fred C. Schollmeyer--Dade County School District
Ms. Josephine Strong--North Sumter Intermediate, Wildwood
Dr. C. Roland Terrell--Florida Junior College

The committee met five times. During the course of these meetings, expert testimony was presented by:

(1) Representatives of Florida school districts, colleges and universities now using instructional computing.

(2) Nationally recognized experts on instructional computing.

(3) Vendors of instructional computing products (hardware and software).

(4) Staff members from the Department of Education.

The staff of the Department of Education also prepared a review of the literature including both published and unpublished reports on instructional computing. In addition, the following surveys were conducted:

(1) Survey of the use of instructional computing in Florida school districts.

(2) Survey of hardware and software for instructional computing in Florida school districts and community colleges.

(3) Survey of instructional computing studies in other states.

(4) Survey of provisions for computer literacy in Florida Teacher Education programs.

A record of committee activities, the literature review, the survey results, the consultants' comments, and other relevant items of information regarding this study are included in the Appendices.

The staff work on this study was performed by Dr. Peggy Roblyer, Instructional Computing Consultant with the Florida Educational Computing Project, and Dr. Fred Daniel, Director of Strategy Planning and Management Information Systems, with the assistance of Sally McDevitt, Graduate Assistant. The sections on cost were prepared by Edgar A. Fresen, Economist in the Department of Education.

This study of instructional computing deals with "computer assisted instruction" as stipulated in the Appropriations Proviso. In addition, it makes reference to computer managed instruction and computer assisted guidance, as appropriate. The scope and applications of instructional computing are explained in Chapter Two.

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I. SOCIETY, EDUCATION, AND COMPUTERS

The proliferation of computer use in the period from the 1950's to the present has rapidly spawned "the computer society." Computers began as limited-use, scientific instruments and have emerged as commonly-used systems, as much a part of everyday life and activity as the automobile. And like automotive technology, the pervasive influence of computer technology has been felt in all institutions in society, including education. To plan and prepare for the future of a "computer society," it is imperative to consider the implications of an increasing dependency on computers as well as their potential to expand and enrich human lives. This examination should first focus on the two conditions which contributed to increased use of computers: the evolution of capability in the technology and the need for tools to deal with a complex society.

A. Evolution of Computer Use

Three unique and powerful kinds of capability have been provided to society by computer technology.

(1) Speed - While early computers were able to perform calculations more rapidly than people, today's models can operate at speeds 50 times as fast as the early versions. Small microcomputers can execute about one million programmed instructions per second and will, in a few years, have the ability to execute four million instructions per second. This means that while we might speak of a task such as finding a student's personal file as taking a few seconds, computer technologists would refer to the retrieval of such an item from computer storage in terms of nanoseconds (one thousandth of a millionth of a second) or even picoseconds (one thousandth of a billionth of a second).

(2) Storage - The incredible decrease in the size of computer components has meant that more and more information and instructions can be stored in a smaller and smaller space. In a matter of a few years, it will be possible to store the contents of a large university library on a one-inch computer chip. The computer which houses this information could be put on a desk top and stored in the corner of a room.

(3) Control - Since computer circuits operate basically like those of other electronic devices, they may be connected to the circuitry of other machines and systems and then programmed with instructions on how and when to run these devices. In this way, a powerful computer can be given the capability of handling an almost unlimited amount of devices, ranging in complexity from a coffee-pot to a hospital life-support system.

It is appropriate to look at computers and the capability they provide as integral components of a high quality of life. Computers are the work horses which release people from time-consuming, mundane tasks in order for them to engage in more creative endeavors.

Computers have played such an important role in the management of information about and for people that there is now an increasing dependence on these machines for most of the vital and valued functions of society. A technology so pervasive can not avoid impacting both the process and products of education.

B. Impact of Computers on Education

The availability of inexpensive, powerful computers both creates new problems for education and also promises new ways of handling some existing educational problems. The crisis predicted for education (Dede, 1979), seems to make it imperative that both these aspects be explored.

Perhaps most evident is that "computer literacy" will become a new basic skill in education. Society has already realized that a person who cannot read is denied access to information and education. It is becoming an acknowledged fact that a person who cannot interact with a computer will be denied even more opportunity for education. Since this could further increase the opportunity gap between rich and poor, the lack of widespread computer literacy is often referred to as "the next crisis in education" (Molnar, 1979). Skill training for the multitude of new jobs in computer technology and for the changes in existing jobs due to technology must also become part of the curriculum if education is to prepare people for future job opportunities.

The components of the educational system (buildings, teachers, supplies, energy, transportation, etc.) are rapidly increasing in cost. At the same time, the system is mandated by Federal and State legislation to individualize the needs of students, but without the support of additional funds. Educational systems are rapidly approaching the state of attempting to do everything, but not having sufficient funds to do anything well.

Computers can help in two ways. First, through better management of resources (with computerized accounting, inventorying, and student record-keeping), the existing funds spent on education can be made more productive. Such methods could make it possible for administrators and teachers to evaluate programs and spot strengths and weaknesses in their methods. Teacher and student time can also be made more productive. Computerized systems may be used to help individualize learning for students at both ends of the performance spectrum. For slow and disabled students, computers can monitor student progress and make possible better

diagnostic and prescriptive techniques. For accelerated students, there is an increased capability for self-teaching and for the development of problem-solving skills through programming and simulations. Both these instructional strategies often result in making availBoth these instructional strategies often result in making available more of the teacher's time to provide attention to individual students. And for all students, computer terminals can be an important delivery system for locating and retrieving information necessary to support learning. Specific methods and products which may be used to make these capabilities possible and practical are described in Section II of this report.

Although the technology has evolved into a useful and powerful aid to educational administration and instruction, the availability of technology will not assure its use in education. Careful planning and attention to implementation concerns are necessary if the potential of computers for education is to be realized. It seems evident that there is much to be gained by this investment in the future. Section III reviews the feasibility issues and concerns which must be addressed as part of the necessary planning. Finally, Section IV analyzes several component costs in making available and using computing capabilities for instruction.

II. COMPUTING APPLICATIONS FOR INSTRUCTION

A. Instructional Computing Defined

Any computing-related activity which is performed in the context of the educational system is usually referred to under the umbrella heading of "educational computing." However, referring to activities in this way tends to obscure the vast differences in purpose and procedures between (1) computing activities to facilitate the logistics of running the educational system (administrative computing), and (2) computing activities to aid the instructional process (instructional computing). The following terms have come into popular use in Florida to discriminate between these two functions:

Administrative Computing refers to computerized activities performed within the educational system in order to facilitate record-keeping and management functions such as staff payroll, inventory, financial records, and student-related management activities such as scheduling and grade reporting.

Instructional Computing refers to computerized activities which facilitate the teaching/learning process, such as actual instruction to students, management of test data on students, and teaching students about data processing functions.

It is important to discriminate between instructional and administrative computing since they are radically different both in purpose and in the methods used to accomplish them. Also, legislation has already been directed toward distribution of administrative computing resources in Florida, and most educational computing capability in the State has been established for administrative computing. On the other hand, very little direction has been provided from the State level for the instructional computing area.

B. Types of Instructional Computing Applications

The following terms are usually used to describe functions or types of instructional computing:

Computer assisted instruction (CAI). The important word in this term is "instruction." The usual CAI activity uses the computer terminal as a medium of instruction, in the same way that a teacher or a workbook aids in the delivery of instruction. Usually, CAI is individualized and highly interactive, allowing each student a self-paced, personal "tutor" for a given topic or content area. It is common to find reference to several kinds of CAI, depending on the instructional method being used in the CAI lesson. Although several of these kinds are often found in the same lesson, it is useful to think of the following terms in order to describe functions which CAI may fulfill to meet individual needs during the instructional process:

(1) Tutorial CAI - This refers to an activity in which the computer terminal delivers pre-programmed instruction in a given content area, similar to a pre-programmed instructional workbook. Tutorial CAI is used as an alternative to a teacher lecture, a film, or a workbook activity. As with any of these media, CAI may be used to provide initial instruction in a content area, or it may be used to provide an extension of content or concepts which have been delivered initially by the teacher or another medium. For example, tutorial CAI would be an appropriate method to use to teach students how to use a microcomputer system, and many micro systems vendors provide such tutorial lessons. It might also be selected for additional instruction in advanced concepts, for example in solving for three unknowns in an algebra system, after students had learned how to solve systems for one and two unknowns.

(2) Drill and practice CAI - These are activities which provide students with a series of practice items on material which has been learned through tutorial CAI or through another medium. Drill and practice CAI lessons are especially useful in providing immediate feedback as students practice their skills, since feedback can help to correct items before students memorize wrong answers. These activities are also valuable in aiding retention of skills in such areas as number facts or grammar rules.

(3) Simulation or modeling CAI - This activity is constructed either by programming the structure or behavior of a real system so that it is shown on a screen or in a printout, or allowing the student to construct a hypothetical model of a system. Simulations are especially useful when it would be too expensive, time-consuming, dangerous, or impractical to see a real system in action. Often, the nature of the content is such that students can learn best by seeing "action models" and altering the variables in the system in order to see the effect of the variation. An example would be a genetics experiment in which the student observes the effects on offspring of pairing animals with given genetic traits.

(4) Gaming CAI - In an instructional context, CAI games are delivered in order to teach or practice skills through motivational activities. CAI games are useful to employ as a reward, or when students need more motivation than usual in order to keep them learning about a particular area.

Computer managed instruction (CMI). CMI activities encompass a variety of functions which are directly related to the instructional process but do not provide instruction in the same way that CAI does. These instructional functions include: administering tests, scoring tests, analyzing test data, and providing summary information on student progress to students, teachers, and administrators. A CMI system may provide any or all of these functions. A typical CMI system is one in which students take tests on machinereadable sheets, and the sheets are scored through a machine. The results are then processed and summarized

by a computing system. The summary may include a diagnosis of problems and prescriptions for further study. Some CMI systems allow students to take the test at a computer terminal, with responses transferred directly from the terminal to the computer. The focus of CMI systems is on relieving teachers from much of the paperwork and record-keeping tasks which accompany individualized instruction.

Other instructional computing applications. Several non-CAI/CMI instructional computing applications fall into an "other" category. These include (1) information retrieval systems which can aid students in locating information about a particular topic, (2) computerized guidance systems, which provide decision-making information to students concerning jobs and schools, and (3) problem-solving activities.

As with much specialized terminology in the field of education, these definitions are not standardized among educators or computer users. Computer assisted instruction is sometimes called "computer aided instruction," for example. Also, some writers and instructional developers list several more kinds of CAI by dividing up drill-and-practice into several functions. In the current report, the terms are used as defined above.

C. Types of Computer Systems for Instructional Computing

Several kinds of hardware systems are available and in current use to provide CAI, CMI, and other instructional computing applications. These alternative systems are described below:

Large timesharing systems. As the name implies, these systems provide a large, centralized capability which may be shared by several users at one time. Required equipment includes a "mainframe" computer with the storage capacity and capability to handle several usersterminals at once, and terminals such as cathode ray tubes (CRT's) or teletypes at which each user may interact with the computer. Although users have a certain amount of control over the immediacy with which their requests to the computer will be handled, ultimate control over the priority of the requests (and even whether or not the request will be accepted), resides at the central computer location.

The same kind of computer which handles timesharing activities may also accept requests which are to be put in a group or "batch" with several other jobs and handled at a later time, in order to free computer time for more immediate needs. Batch requests may be made by users at a CRT or teletype terminal, or at a machine which accepts punched cards. With batch systems, users have even less control over how soon the request will be handled than they do with timesharing systems. Priority again is assigned at the central computer site.

Small/medium time-sharing systems. These systems have the same time-sharing and batch procedures as with mainframe systems, but the computer which runs the applications is somewhat smaller in terms of memory capacity and power. It is called a "mini-computer," rather than a mainframe, and is usually able to handle less terminals at one time. The control from the user's point of view is the same as with a mainframe, however.

Standalone microcomputer systems. Currently the major difference between this system and the others from the users' point of view is control. "Standalone" means that the system is entirely selfcontained, since both an input/output terminal and a small processor (microprocessor) are in the same physical location. Since an individual user has complete autonomy over how and when a request will be handled, these systems are often called "personal computers." However, this kind of system is presently limited in capacity and capability, and cannot perform all the kinds of instructional computing tasks which can be done on larger systems. Microcomputers are presently limited in the amount of storage available for applications such as CMI record-keeping.

Time-sharing/standalone microcomputer systems. A recently-added capability with some microcomputer systems is the ability of microcomputers to act as "temporary terminals" to a time-sharing system until the user receives a desired CAI program. Then the communication link with the main computer is broken and the microcomputer may run the program (and accept other programs locally) as a self-contained unit. This increases many times the capability of a given microcomputer system for instructional purposes.

D. Applications to Educational Problems

Use of computing technology in support of teaching and learning first received widespread attention in the late 1960's and early 1970's. At that time there was a popular opinion among educators that the power of computers could solve all or most of the problems which were apparent in the educational system. When it became evident that instructional computing offered no such panacea, there was general disillusionment concerning the use of these and other innovative methods for instruction.

Since these early endeavors, computers have become even more powerful and less expensive, and a great deal has been learned about what computers should and should not be expected to accomplish. In light of this new knowledge, it is appropriate to ask the following questions:

(1) Are there specific educational problem areas for which instructional computing methods may be a solution?

(2) Are there specific ways instructional computing resources can enhance teaching and learning?

In response to the first question, there are several kinds of special-needs student populations which can and do benefit from such methods. (See Appendix E, particularly comments by Alfred Bork.) These students have traditionally represented some of the most difficult, expensive, and time-consuming learning problems presented to classroom teachers. Without instructional computing methods, these students may never receive the attention they require. The special-needs populations include:

Students requiring remediation in basic-skills. Florida has already recognized the need for re-teaching functional literacy skills to students experiencing difficulty in this area. Computerized methods can help with this task in two ways: (a) By providing drill-and-practice to develop rule-learning skills and to enhance retention of learned skills, and (b) by supplying an automated system of tracking student progress and supplying specific, individual information on areas of student weakness.

Students with learning disabilities. Again, both drill-and-practice and management capabilities can help with the learning problems presented by many kinds of learning disabilities. A medium such as CAI is able to provide the constant patience, reinforcement, and stimulation required for these students.

Students in low population courses. Content areas such as advanced mathematics (trigonometry, calculus) and advanced science (physics, chemistry) are often considered low-priority areas for staffing since they do not draw large numbers of students. Computer-based methods can help supply self-paced learning environments for these and other areas where teachers are often unavailable.

Accelerated learners. Remedial instruction for slower learners is sometimes provided at the expense of attention to gifted learners. Since gifted students are also entitled to an appropriate educational program, and since these students are an important future resource for society, there are currently programs underway to provide better instructional environments for the gifted. Computers can help by offering a powerful intellectual tool with which the student can explore all content areas, and by making possible self-paced methods for learners to acquire further knowledge and skills.

Transfer students. There are many students who, for a number of social and personal reasons, move frequently from school to school. These students may have no learning difficulty other than simply getting access to material which they missed by transferring to a school with a different curriculum structure. Self-paced methods offered by CAI and CMI again seem a logical solution to this problem.

A review of research on the uses of instructional computing methods (Appendix B) provided some answers to the question of specific ways in which such methods can enhance teaching and learning. It is apparent that computerized methods can be an effective solution for special-needs populations because of unique capabilities in three key areas:

Individualization and self-pacing. Both computerized management and instructional methods are helping provide individualized learning environments for a broad spectrum of content areas and learning levels. CAI and CMI have been especially useful in the teaching of mathematics and reading at the elementary level. Such methods have also been used successfully to help individualize instruction in community college and university settings. There is consistent evidence from the research that CAI is at least as effective as traditional methods and is often more effective, especially when used as a supplement to regular instruction.

Motivation. There is general support in the research for the view that computerized methods of all types promote more positive student attitudes toward both the content and the instructional approach. Computer-based, individualized learning methods seem to provide a "teacher" with endless patience and unlimited memory concerning each student's specific learning needs. The capability of supplying private, tailored, and immediate feedback to the student appears to be largely responsible for increasing students' motivation to learn.

Interaction during learning. Many reports indicate that a large number of learning problems result from learning in a passive rather than an active environment. Large numbers of students for a given classroom often make it necessary to use lecture and other methods in which the student is not actively involved in each step of the learning process. Computer-based methods can help provide a setting where the student has access to "personal" interaction at any time.

There is evidence that better methods of individualization, together with increased motivation and more interaction during learning can cut down substantially on the amount of time needed for students to acquire skills and knowledge.

E. Illustrations of Current Instructional Computing Uses

The benefits of computer-based methods to teachers and students are not merely theoretical. The potential of computing resources to enhance education is already being realized, both in Florida projects and in the activities of organizations in other states. Much has been learned from these efforts about the positive aspects of instructional computing, as well as the practical problems which must be addressed on a continuing basis.

CAI in a statewide system. The Minnesota Educational Computing Consortium (MECC) is a recognized leader in providing instructional computing support to a statewide educational community. MECC provides applications of several kinds to schools, colleges and universities throughout the state. Both time-sharing and microcomputer systems are employed. Most CAI activities take place via a microcomputer-based approach. As of the beginning of 1979, approximately 500 APPLE microcomputers were in place, each able to act as a standalone unit or as a terminal to MECC's mainframe computer. Under the MECC system, CAI and other applications can be sent to a given microcomputer, the communication link broken, and the application run independently at the local site. MECC administrators report that this system works well and supports learning activities in a number of content areas.

The key to the successful administration of the MECC system seems to be a user services staff which performs four kinds of activities:

(1) Coordination - Instructional computing coordinators respond to user problems and train personnel in the use of system resources. Newsletter, training workshops, and conferences are some of the elements used to maintain contact with users.

(2) Courseware quality control - New CAI packages are reviewed and evaluated on a continuing basis to add to the existing library of CAI resources. Approximately 50 self-instructional modules are available to users at this time, in addition to support materials for use with these modules.

(3) Technical support and development - The MECC staff continues to monitor new technology in an effort to arrange volume purchase agreements on hardware and software which can enhance the services available to users.

(4) Distribution - Both documented courseware and written support materials are disseminated on request to members of the educational community. Efforts are made to keep members informed about available materials through conferences and newsletters.

MECC reports a steady increase in the number of users applying for and receiving instructional computing resources. Plans are to expand the present microcomputer-based program as more courseware and better technology becomes available. MECC administrators continue to emphasize the need for user support services, regardless of the type of system employed.

Computer-based instructional management. A Florida project which has received widespread attention both within Florida and from other states is one developed at Miami-Dade Community College: The Response System with Variable Prescriptions (RSVP). RSVP is essentially a CMI system, but is often referred to by its developers as a "computer-based instructional management" system.

RSVP was originally designed as a support system to facilitate handling off-campus and individual study courses at Miami-Dade Community College. However, it is also used in conjunction with on-campus courses in several disciplines, including natural and social sciences, psychology, history, humanities, and basic skills instruction. Approximately 35,000 students have some kind of contact with RSVP each term.

For each course in which RSVP is employed, college faculty work with Miami-Dade technical personnel to develop diagnostic and prescriptive materials for use with the system. Then, student test data and teacher evaluation data are analyzed using the RSVP computer programs. The system provides feedback to students and teachers on areas of strength and weakness. Reports to students are individualized, computer-generated letters commenting on performance and specifying instructional activities for each student's particular needs. RSVP administrators report that the CMI strategies have been accepted by the faculty and students mainly because of the quality and flexibility of the system and because of the continued support and training provided as part of the RSVP program.

Computerized guidance systems.- Perhaps more than any other kind of instructional computing application, computerized guidance systems have been well-received by both students and instructional personnel. The limited availability of guidance counselors at junior high, senior high and college levels is widely recognized as an educational problem. Guidance systems such as DISCOVER have helped provide an effective solution to the problem in several locations in Florida including Orange County School District, Dade County School District, Hillsborough County School District, Palm Beach County School District, and Palm Beach Junior College. Orange County School District also provides DISCOVER to several other school districts and community colleges in the region.

The DISCOVER system contains a series of modules with activities ranging from values clarification to job exploration. Students access these activities through interactive terminals connected to a mainframe system. As students go through the modules, information is gathered on their values and aptitudes to help them in their decision-making process.

System users around the state report that DISCOVER continues to generate student interest in career choices and in computer activities and capabilities, as well. Thus, the system acts as a computer literacy tool, as well as a guidance medium. Users also report that, because of its interactive nature, it can effectively simulate the activities of a guidance counselor and provide students with useful, up-to-date information on jobs and educational institutions.

Summary of Illustrations. For each of these successful programs, there seem to be key components at work. First, there is an initial and continuing need for adequate teacher training and preparation. Some of the personnel in these projects had initial negative reaction to using technology which had to be overcome before training in system activities could begin. Each project also emphasized the necessity for administrative commitment in order to support the time and personnel resources required for the project. Finally, each project recognized the importance of on-going support and technical assistance structure to maintain the high quality and effective use of the resources made available initially.

III. PLANNING FOR THE FUTURE IMPLEMENTATION OF INSTRUCTIONAL COMPUTING

The current interest in making computers an integral part of teaching and learning activities promises nothing short of a revolution within the educational system. As of November 1979, there were more than 250 microcomputers and over 600 timesharing terminals being used for instructional purposes in Florida school districts (see Appendix C). In a year, the figure for microcomputers could easily double. Yet it is apparent that present activities are often exploratory and pilot in nature. As the U.S. House of Representatives (1978) Committee on Science & Technology discovered in its study of the impact of technology on schools, the educational community lacks a "coherent, rational policy toward the use of computers for improving learning in our society." The study emphasized the urgent need to plan implementation strategies for taking full advantage of computing technology in education.

Planning needs to be of two kinds. There is a requirement for a management system of disseminating quality instructional computing resources, and for providing the training and technical support to facilitate effective use of the technology. However, strategies must also be considered for dealing with current perceptions about computers for instruction. Witnesses to the U. S. House committee were agreed that "just because something works is not a guarantee that people will flock to it." A significant factor in the success or failure of instructional computing may be how adequately an implementation plan takes into account certain controversies and issues which are apparent in this area.

A. Management Concerns

The experience of other states with instructional computing has been that a centralized, rather than a localized, method of planning and providing support functions is more facilitating to the growth and effective use of instructional computing in a state-wide system. If members are left essentially to their own activities, use of technology will flourish in some areas and be largely unknown in others. It seems imperative that all students be given the learning opportunities which instructional computing has been shown to provide. Systematic planning needs to be done to assure that the following concerns are addressed:

Hardware/software needs. Some kinds of delivery systems and ways of using them were described in Section II.C. There is currently considerable discussion in both the technical and educational communities about the size and capability required in a hardware configuration for instructional use. There are also concerns over the availability of instructional software for use on these hardware systems.

The technology seems to be moving toward smaller, increasingly powerful standalone microcomputers as instructional delivery systems. Although there are large, timesharing systems available for instruction there often seem to be more costs and logistical problems associated with implementing these than with microcomputer systems. However, since instructional personnel can easily become confused about various vendor claims for their products, they are often in need of advice and direction on what kinds of purchases to make to meet their needs. Currently, expertise to deal with these questions, as well as access to the hardware itself, is often centered in the more affluent school districts.

Perhaps the most difficult problem to resolve is how to assure an adequate amount of high-quality instructional software (courseware) for various instructional content areas and target populations. It is often overlooked that the effectiveness of CAI depends almost totally on the quality of the lesson material. Although there are a number of microcomputers and timesharing terminals in schools at this time, course is often scattered and of inconsistent instructional quality.

It would facilitate effective use of instructional computing products if there were a centralized system for disseminating information on CAI courseware. This might also include the distribution of copies of the courseware which would then be used on local hardware. Such an approach would be comparable to the Department of Education's current system for distributing instructional television materials. While experience in this area is limited, it appears that providing either information about computer-based products, or supplying the products themselves, is integral to the successful use of CAI and CMI.

Teacher training needs. The history of innovative programs in school systems has shown that success of the effort depends upon adequate training and preparation for the personnel who will implement the program. Teachers who are unfamiliar with, and perhaps apprehensive about computer technology, require a well-designed and comprehensive orientation program in both general computer literacy and in the use of the specific system to be implemented. It seems apparent that this orientation cannot be done quickly, in an after-school workshop environment. Some awareness of computer technology needs to be stimulated during teacher education programs, in addition to providing inservice training in the specific CAI/CMI materials to be used.

At this time, computer literacy is not addressed in any comprehensive way in Florida teacher education. A survey of Florida teacher training institutions (Appendix C) reveals that few programs require computer literacy at any level as part of the skills for teaching. Clearly, more emphasis needs to be placed on this training if instructional computing applications are to be accepted into classroom use.

Management training needs. The orientation and training of management personnel is just as vital to the successful implementation of innovation as adequate preparation of teachers. Perhaps even more important is the requirement for broadly based orientation in management principles for such personnel. Both kinds of programs are needed: (a) to develop awareness of computer technology and the potential of the technology for improving instructional programs, and (b) to assure the development of a support system for maintaining the utilization of technology. Vehicles such as the Academy for Management Training established by the 1979 Florida Legislature can be useful in providing needed orientation for educational leaders.

Continuing support requirements. Once the initial elements of the dissemination plan are set in motion, provision must be made for maintaining the quality and effectiveness of the activities. This is especially true in light of the changes occurring daily with technological products and services. Again, a centralized approach needs to be adopted to accomplish the following kinds of functions:

(1) Purchase agreements - Most vendors of computing equipment and software are willing to allow substantial discounts and will even include additional services, if they are approached from a systemwide level, rather than by individual districts or institutions. Several of these agreements have already been made for educational computing products and have resulted in considerable cost savings for the State.

(2) Technical information resource - Often, instructional personnel are interested in acquiring instructional computing products, but do not know where to begin looking for such products. They need a resource which could provide such technical assistance initially and later help identify problem areas and suggest solutions during implementation. Such a requirement is especially evident at this time in smaller, less-affluent areas, which do not have technical resources of their own.

(3) Communication channels - The Florida Equitable Distribution Plan for administrative computing resources is based on the knowledge that many technical resources which are available in more affluent areas may be shared with neighboring, less-affluent members. The key to encouraging this sharing activity is communication among members of the system. It has been demonstrated that encouraging communication for purposes of sharing technical knowledge and products can do much to make better use of existing resources and thus make the system as a whole more productive.

(4) Evaluation activities - It is important that some efforts are made to evaluate the progress of instructional computing programs, in order to determine ways of revising them and making them more effective. Such documentation has been seen as a necessary formative component in assuring the continued success of any instructional activity.

B. Implementation Issues and Concerns

Since the earliest days of experimentation with teaching machines, there has been intense, often emotional, debate over the use of technology to instruct students. Now that computing technology has become a pervasive presence in school settings, the discussion has become even more intense and more sharply focussed on certain high-profile issues. Some of the issues have to do with employing any methods other than traditional ones. Systematic planning for the dissemination of innovative methods and materials can help address these. However, there are also concerns unique to the use of computerized methods--questions about the potential impact of this powerful and expensive medium on students, teachers, and on the educational system itself. These questions may not be easily answered, but they must be carefully considered when selecting methods and strategies for implementing instructional computing:

The management of change. Can instructional computing as a form of technology be successfully introduced in the schools, colleges and universities of Florida? Deans, superintendents, principals, coordinators, assistant superintendents, provosts, presidents, and other officers in the educational establishment must have a clear understanding of the potential of instructional computing in order to view it as an opportunity for progress and improvement in education. This presents somewhat formidable considerations in organizational development. Strategies must be planned for organization development capabilities to insure appropriate adoption of innovations available with instructional computing. Unless opportunities are provided for key individuals in educational management to gain tools and concepts to aid the introduction of computer technology, the necessary changes in the system may never take place. Public policy considerations should also be carefully considered as a part of this need.

Impact on learning. Does instructional computing make a difference? If scarce educational dollars are to be spent on relatively high-cost technology, many people want some assurance that the results will be improved learning. There is strong evidence that instructional computing can indeed make a difference in several key ways. Computer-based methods have consistently been shown to be at least as effective as traditional ones, and are usually more motivating to students. Self-pacing and individualization become more practical to implement. It is also evident that use of self-instructional methods can take less time to achieve learning gains, and that the teacher's time can also be made more productive through computerized management techniques. This combination of characteristics offers tremendous potential for educational problem areas such as remedial basic skills instruction.

Effects on teachers. Will the role of the teacher change? There are fears on the part of parents and teachers that computers will be used to replace many of the vital functions which teachers now perform to facilitate learning. While it is neither desirable nor likely that this would happen, it does seem apparent that, as computerized methods and materials become more effective and useful, proper planning could allow teachers' roles to shift gradually from delivering information to those of managing the instructional process. Teachers could have more time for guiding individual progress, while computerized resources perform time-consuming drill and record-keeping activities.

Effects on students. Will instruction become impersonal? Many people envision a scenario of future education where students are totally isolated from human interaction during learning, and as a result, become robot-like, unsocialized, and conformist. Again, it is neither desirable nor likely that all instruction should take place via computerized methods. It will be necessary, however, for decisions to be made about how much time should be spent in individualized versus group methods of learning. Further research is needed about the effects of each of these methods on individual self-perceptions and development. It is also imperative that we address issues concerning the role of the physical school center. Should it continue to have as a major function the socialization of citizens for society, or will energy shortages and other environmental conditions make it necessary to revise completely the structure of public education?

Large vs. small systems. What kind of computer system is best for instructional use? Even the hardware systems selected for instructional computing uses have implications for the ways in which teaching and learning will take place in the future. Although microcomputers represent a small initial investment and offer much flexibility and autonomy to students and teachers, there may be problems with quality control and use of instructional materials. Large mainframe systems, on the other hand, are more centrally-controlled, and offer standardization of instructional material, but many perceive a potential problem in meeting local, special-purpose needs and allowing for diversity and optional approaches if development and dissemination are centralized in this way. There are also discussions concerning the costs of mainframe versus microcomputer systems as delivery systems. Some of these issues are addressed in more detail in Section IV.

Availability of quality courseware. Where will instructional computing materials come from? The development of courseware has been shown to be an expensive and time-consuming process. It is also a procedure which requires several kinds of expertise in order to produce a quality product. Although it does not seem likely that individual teachers will be expected to produce large amounts of courseware, it is also unlikely that a state system will be able to allocate scarce educational funds for such development. The answer may lie in gaining access to materials

developed by the private sector and by groups chartered for such development activities. If this strategy is used, there will still be a need for centralized coordination to evaluate and disseminate these materials to users.

Computer literacy needs. How much literacy is enough? Computer literacy for teachers has been identified as a priority need if the technology is to be adopted into the system. However, the whole topic is very threatening to many teachers, and there is often resistance to adding more complex skills to already-loaded teacher education curricula. While it seems likely that it will be important for teachers to have at least a basic acquaintance with the technology, planning efforts must include identification of the level of knowledge which is practical for all teachers to acquire. Beyond this level, instructional/technical liaison personnel may be necessary.

IV. ANALYSIS OF INSTRUCTIONAL COMPUTING COSTS

Numerous organizations consider computers to be almost indispensable for survival in an increasingly complex environment. In some cases, gains in productivity derived from computer applications have resulted in substantial reductions in cost and increased quantity and quality of services. However, these gains in productivity and efficiency have not occurred uniformly. Such areas as research and development, financial management, governmental regulation, and other fields which deal with large amounts of information have been the beneficiaries of computer technology. Other sectors, particularly those which provide services tailored to the needs of individuals, have been less able to participate in these benefits.

Several applications of computing to instruction were described in the preceding pages. With the rate of advances in computing technology, it appears that these applications will become increasingly available. Moreover, because of the growing use of computers in society, it is important that education use them appropriately. The tools for processing information in the larger society must certainly be available to aid learning. Thus, from a societal perspective, education cannot afford <u>not</u> to invest in computers for instruction.

A. Analyzing Cost Effectiveness

While investment in instructional computing appears essential, traditional considerations of cost effectiveness cannot be overlooked. Basic issues in cost effectiveness are described below.

The allocation of scarce resources to deal with social needs is a fundamental concern. Ideally, a sequence for performing a cost-effectiveness analysis for an area such as instructional computing would be as follows: It would be determined if expenditures in this area can provide greater benefits to society than investments in other areas such as transporation, housing, communications, or even other educational programs. If instructional computing were identified as the program which can produce the greatest benefits for the lowest cost, an evaluation of alternative strategies available for its implementation would be conducted. This process, which is commonly known as cost-effectiveness analysis, can be oriented in two ways: the first attempts to answer what is the maximum level of output which can be produced through each alternative strategy for a given amount of resources; the second attempts to estimate the different costs of producing a given level of output. The final step in this process would be the selection of the most effective alternative.

Although considerable effort has been devoted during the last thirty years to the development of such techniques for conducting cost-effectiveness analysis, these methods have only recently been considered in the field of education. The delay in the adoption of these techniques as working tools for educational analysis is explained by the fact that the criteria used for decision making in those sectors which have benefited from this approach are substantially different from those in education. In addition, most of the requirements for conducting sound cost-effectiveness analysis are difficult to satisfy. This is particularly true in the area of instructional technology, given the existing knowledge about the factors which affect educational outcomes.

Evidence of the lack of cost-effectiveness information in the area of instructional technology is provided in the literature cited in Appendix B.3. One author identified over 400 references related to this topic. In a review of over 300 of these references, he was able to identify only 32 which contained results supported by either quantitative or empirical data. Even those studies which include some data simply allocate costs across departments and programs without providing a clear picture of resource consumption. Finally, there is inconsistency in the use of terminology related to the evaluation of educational technology. Such terms as cost-benefit analysis, cost-effectiveness analysis, cost-utility analysis, and systems analysis are often used interchangeably in the literature.

Considering all of these limitations, only a tentative and faint picture of the cost-effectiveness of instructional computing can be advanced at the present time. Based on a literature review it appears that in most cases CAI presently costs more than conventional pedagogical methods; however, for some kinds of instruction, it may be cost-effective and is becoming more so as hardware and software become amortized over time. In the case of CMI some cost advantages over conventional instructional methods have been reported. These advantages are more evident in higher education programs, but have also been observed at the elementary and secondary levels as well.

B. Comparative Costs of Computer Systems for CAI

Two CAI strategies were considered in analyzing cost-effectiveness: time-sharing and microcomputers. Each one of these two alternatives was analyzed in terms of the cost of producting a given level of output.

The analysis was conducted on a sample which includes three time-sharing systems and fifteen microcomputers. The list of microcomputers and the minimal definition for a system used in this report were those developed by the Minnesota Educational Computing Consortium (MECC). A minimal system, according to this definition, is one that is "educationally useful and usable for the majority of the computer users in schools and colleges." The characteristics of such a system are listed in Appendix D.

The information contained in Table 1 suggests that the variations in total fixed and maintenance costs for CAI are significant. This information, however, can only be used tentatively since (1) software costs have not been included in the analysis, (2) this information is subject to change in the near future due to the dynamic nature of the computer industry, (3) this analysis is not concerned with the computing and processing time of these systems which is a criticial factor in evaluating cost-effectiveness, and (4) depreciation and other determinants of cost-effectiveness were, for the purpose of computation, assumed equal for all systems.

Additional information required to complete a cost-effectiveness analysis deals with the effect of scale of operation and duration of the program on the cost per unit of output. It appears, however, that microcomputers, given their divisibility into smaller units of cost, may be optimal for a wide range of output volumes. It is also reasonable to assume that minimum cost per unit of output can be reached in shorter periods of time with microcomputers than with large computing systems.

TABLE 1
COST PER HOUR* FOR PROVIDING COMPUTER ASSISTED INSTRUCTION WITH SELECTED MICROCOMPUTER AND TIMESHARING SYSTEMS

	Cost Per Hour
Microcomputer Systems	
Apple II-32	.38
Hewlett-Packard-9845B	2.03
IBM-5110	3.22
Radio Shack TRS-80 (Level II)	.32
Timesharing Systems	
FSU Computing Center (CDC PLATO)	3.12
Northeast Regional Data Center (AMDAHL-IBM Compatible)	3.14
Southeast Regional Data Center (UNIVAC 1100)	2.17

*Includes fixed and maintenance costs only. Based on use 7 hours per day, 22 days per month, 12 months per year. For further information, see Appendix D.

V. CONCLUSION AND RECOMMENDATIONS

Throughout history, there has been an evergrowing collection of tools to help teachers teach and students learn. Some, such as the chalkboard and the textbook, have become universal. Others, such as films, filmstrips, overhead projectors, calculators, models and laboratory apparatus, have become common. Computers, perhaps the most powerful of the teaching aids, have in the past been considered too expensive for general use. Thus, they are found primarily in industrial training programs, in scientific and technical programs, and in programs with special supplementary funding, rather than in public education. Part of the reason is also that, as was mentioned previously, there exists in public education no "coherent, rational policy toward the use of computers for improving learning in our society" (U.S. House of Representatives, 1978).

New technology has spurred a boom in the field of electronics. Computing equipment which cost millions back in the fifties can be bought for a few hundred dollars, and prices are still going down. Future electronic appliances for education and amusement will be even less costly, more useful and more common. Computers are in some homes today, will be in many homes tomorrow, and will be commonplace in the not too distant future. Given current problems in Florida education (i.e., concern with overall quality, the level of students' basic skills performance, shrinking resources, concern for equal access and equal opportunity), and an understanding that computer hardware is one of the few areas of modern life where costs are declining, the time seems right for an infusion of new technology into the educational system. The unique capabilities of computers make them an ideal adjunct to the educational process. With computers, individualization and self-pacing become more feasible. This is due to the fact that, with the aid of computers, a teacher can keep track of various information on individual student progress. Also, when the computer is used to deliver instruction, it can do so with infinite patience.

Still, computers are not a panacea. They depend upon skilled human beings who prepare the instructions--the software and courseware. Fortunately, with more and more inexpensive computing devices coming onto the market, more and more people are devoting their talents to writing instructional courseware for this new equipment. This leads, of course, to the problems of distribution and quality control. With more materials on the market, it will be extremely difficult for most teachers to keep abreast of new releases and to evaluate them for use in their classes. Consultation and technical assistance will be needed. This holds true for hardware, as well as software. Anyone who has looked at a computer magazine recently has found a bewildering array of slick advertisements. It is difficult to know what one should buy.

Even a more basic question is "whether one should buy." The cost studies on instructional computing are rather tentative and somewhat inconclusive. While it is possible to compare costs of hardware, the key factor may be the software. While each piece of software has a price, the effectiveness of that software with a given population of learners frequently cannot be predicted. Even when proven software is available, it is difficult to assign a monetary value for a given level of achievement. Is it a good investment to spend more than the normal instructional cost to get achievement gains from students who have been chronic failures in the past? When compared with the cost of incarceration or other public support, this is probably a bargain. But could the same results be obtained at less cost? While the issue of cost raises endless questions, there is one conclusion which can be drawn: the cost of computing will continue to go down, while the cost of virtually everything else is rising.

A. Assumptions on Which Florida Public Policy Should Be Based

The Commissioner's Advisory Committee on Instructional Computing has reached concensus on a group of assumptions which may serve as a basis for public policy to be formulated by the Florida Legislature. These assumptions are the product of a review of pertinent literature, exchange between the Committee and nationally recognized expert consultants in this area, and much deliberation and reflection by Committee members and staff persons over a period of six months. The assumptions imply the existence of needs which must be met in Florida during the remainder of this century, with implementation to begin immediately. The assumptions are:

(1) Computer technology will play an increasingly pervasive and dominant role in American society during the next generation. Thus, Florida cannot afford not to invest immediately in this technology for the schools, colleges, and universities of the State.

(2) Economic development in Florida demands public investment in computer technology to prepare its citizens for new employment and upgrade the skills of those already employed, in order to attract the necessary diversification in the economic base of the state.

(3) Computer technology has great potential and promise for improving pedagogy and enhancing learning in relation to the basic mission of all schools. That is, computer technology can assist in the development of both basic skills and advanced skills to help all individuals in the Florida educational system continue life-long learning.

(4) There is a clear and unequivocal need for a rational statewide plan for the utilization of computer technology in the educational system of the State. The growth of computer technology in the culture makes it imperative that there be sound planning on the basis of state policies.

(5) The Florida Department of Education has a responsibility to facilitate the appropriate utilization of computer technology in the State. The Department should fulfill this responsibility through the functions of disseminating information, providing technical assistance to school districts, community colleges, and universities, and exploring appropriate roles for the Department in the adoption and utilization of computer technology for instructional purposes.

(6) All professional personnel in Florida school districts, community colleges, and universities must achieve a minimum level of so-called media literacy. Media literacy, which includes computer literacy, encompasses modern methods of communication and data processing technology and appropriate applications of that technology.

(7) Concomitant with the development of media literacy on the part of the personnel of the state educational system, computer literacy must be introduced into the curriculum of elementary and secondary schools and into the colleges and universities of Florida as rapidly as feasible.

(8) The great diversity of products available in the market place and the rapidity of change in the development of computer technology require that Florida not commit itself to any single statewide approach to instructional computing, nor to any single hardware configuration throughout the State.

(9) The adoption of technological aids by school districts, colleges, and universities should be at the discretion of those agencies without Legislative mandates.

(10) The growing pervasiveness of computer technology in all areas of society makes it both necessary and feasible that public education organizations collaborate with other public agencies and with private enterprise in planning effective ways of using technology to facilitate teaching and learning. Public education should especially work with the private sector to take advantage of computer technology now available to Florida citizens in their homes.

B. Policy Formulation

The Commissioner of Education should recommend to the Florida Legislature specific means for meeting the needs implied by the assumptions which are listed above. Based on these recommendations, appropriate amendments to the statutes or new statutes should be considered by the Legislature so as to facilitate utilization of instructional computing throughout the State of Florida.

The Department of Education should establish appropriate management strategies to facilitate effective use of instructional computing capabilities to teach basic skills and other areas where urgent instructional needs have been identified. These strategies could include broadly representative task forces which can propose plans for meeting identified needs through technical assistance. Areas of need fall under two general categories: computers as a medium of instruction and computers as an object of instruction.

Computers as a medium of instruction

(1) Basic skills - The Department of Education has made a significant investment in using the PLATO computer-based instruction system for improving instruction in remedial mathematics. Similar projects should be engendered to include other instructional systems. The State should provide technical assistance to users of the other systems comparable to the assistance being provided to PLATO users. The State should also sponsor the systematic evaluation of the effectiveness of instructional computing uses.

(2) Computers for problem-solving - A program for gifted students on using computers for problem-solving has been developed in Florida and is now being disseminated. The materials have been used successfully with average, as well as gifted, students. Also, microcomputers are being purchased by many schools for use in advanced mathematics classes and elsewhere. Information on these and other current activities which could be used by others in the State should be disseminated by the Department of Education through the computer literacy workshops, professional meetings, and in response to direct requests. The Department, in cooperation with appropriate professional organizations, industry groups, and others, should promote computer fairs or other special activities designed to encourage and publicize creative uses of computers by students.

(3) Education for the handicapped - The Department of Education, through the Bureau of Education for Exceptional Students, should investigate possibilities for utilizing computers with physically, mentally, and emotionally handicapped students.

(4) Low enrollment courses - The Department of Education should survey schools to identify needs for courses in advanced subjects which are not now offered because there is insufficient staff for such low enrollment courses. The Department should also survey available courseware for meeting those needs. Where feasible, arrangements should be made to assist those who could offer such programs, either through timesharing services from a large data center or by microcomputers at the local site.

To assist in the dissemination and acquisition of materials necessary to support each of the above areas, the Department of Education should establish a clearinghouse of information on software, hardware, and other available materials, both inside Florida and elsewhere, to use in each area of need. Information from the clearinghouse should be supplied on request and through appropriate dissemination strategies identified by the Department.

Computers as a medium of Instruction

(5) Computer literacy for educators - Initial work in this area was performed by the Florida Educational Computing Project through the computer literacy seminar which has been presented several times at various locations throughout the state. This seminar is now being adapted for use in local school district inservice education programs. A project should be established during 1980-82 to introduce this program, including the training of local seminar leaders, in all 67 school districts.

(6) "Advanced" computer literacy - A more comprehensive computer literacy course, designed to follow the introductory seminar, should be developed and made available through inservice education programs in the larger districts and on a regional basis for smaller districts. This course might be designed with separate components suitable for teachers in different instructional areas, or for teachers who wish to use various applications of instructional computing.

(7) Computer literacy for preservice education - Appropriate computer literacy units should be designed for use in pre-service teacher education programs. These units should be included within the required courses in each state-approved teacher education program.

(8) Vocational and professional fields - A study of computers in vocational education should be conducted by the Vocational Education Advisory Council. This study should be concerned primarily with training programs in the computer-related fields and secondarily with training programs in other fields which make use

of the computer. The report of the study should include the following: (a) a survey of training programs in public universities, community colleges and vocational technical centers on the adequacy of the curriculum and the opportunities for computer access in computer related fields and (b) recommendations for action, as necessary, to strengthen and/or expand these programs.

(9) Computer literacy for all - An underlying goal of instructional computing efforts should be to provide computer literacy for all students. This will be accomplished in many ways, beginning with computer literacy for educators. Students will develop computer literacy as they participate in instructional computing programs for the basic skills and various other instructional computing activities. There will also be a need for programs designed especially to teach computer literacy. Textbook selection committees should consider computer literacy as they review textbooks. Teachers designing instructional activities should seek opportunities to develop computer literacy in their students.

C. Priorities for the Implementation of Policies

The Commissioner's Advisory Committee on Instructional Computing believes that policy should be established by the Legislature and the State Board of Education to fulfill the needs implied by the assumptions in Section A. The implementation of the policies thus formulated should be undertaken according to priorities in the sequence shown below. These priorities are suggested because the Committee believes that instructional computing is such a fertile field for development in the State of Florida that it is obvious that it is not possible to address all problems simultaneously and immediately. The sequence of priorities for the implementation of instructional computing recommended by the Committee is as follows:

(1) Improving diagnostic techniques and instruction for the basic skills at all levels of the educational system, particularly in the remedial and compensatory programs.

(2) Simultaneous with the improvement of instruction in the basic skills, there must be systematic efforts to develop minimum computer literacy among both educators and students throughout the State.

(3) Continued development must take place in vocational and other professional fields where computer skills are necessary for employment so as to add to the impact of economic development throughout the State.

(4) Broader utilization of computers for problem-solving must be undertaken, beginning with programs for gifted students in the schools and extending to all programs.

(5) Specialized applications of computer technology must be utilized on behalf of the handicapped.

(6) Computer technology must be utilized in curriculum areas where they is low student enrollment.

D. Recommendations for Support of the Policy Implementation

The Florida Department of Education has, under the leadership of the Commissioner, the responsibility for coordinating efforts to support the use of computer technology in a rational manner. It is therefore recommended that:

(1) The existing Department of Education group, the Florida Educational Computing Project (FECP), be funded and adequately staffed to support instructional computing in a comparable manner to that currently provided for administrative computing.

(2) As budget decisions are made in the course of planning for the next biennium, the Commissioner request appropriations to serve as the basis of incentive funding to be made to school districts, community colleges, and universities in order to promote and encourage appropriate and effective utilization of computer technology throughout the State.

The FECP, mentioned in the first recommendation, should carry out the initial support functions which are desirable and necessary in order to accomplish the implementation priorities already described. These support functions, which should also make computer technology available to Florida's educational system at the least possible cost, are:

(1) Providing information and consultation on available hardware and software and the use thereof.

(2) Maintaining a catalog and inventory of available resources, including software, for instructional computing in Florida school districts and other educational institutions.

(3) Securing discounts on hardware and software on behalf of school districts and institutions.

(4) Providing technical assistance to school districts and institutions on individual problems related to instructional computing.

(5) Facilitating and coordinating the evaluation of instructional computing projects.

(6) Providing leadership and staff assistance to Department of Education staff members in relation to the priorities recommended for policy implementation.

Although the Florida Educational Computing Project has been carrying out many of these functions, the efforts of the Project staff have been primarily in the area of administrative, rather than instructional, applications of computer technology. The mission of the Project must therefore be enlarged to clearly charge it with the above support functions in order to serve in a linking role between schools, vocational education institutions, community colleges, universities, and all departments and divisions of the Department of Education.

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